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ROBUST DETECTION OF A REFERENCE IMAGE DURING MAJOR PHOTOMETRIC TRANSFORMATIONS

Preamble to the Specification

Field Concerned, Problem Posed

[0001] The present invention pertains to a method and a system for identifying a specific image and/or a specific audiovisual sequence within any flow of images or of audiovisual sequences, and in particular with the prospect of being able to identify a proprietary image within the flow and/or of being able to identify, preferably in real time, a plurality of proprietary audiovisual sequences within the flow.

[0002] In the field of monitoring protected audiovisual contents, one of the problems concerns the identification of a proprietary video sequence during its broadcast. Since a video sequence is a stream of images, the solution to the problem implies being able to detect and identify a particular image (called a reference image) in real time, while being robust during a certain number of photometric transformations, which may affect the image during its broadcast.

[0003] The solution to this problem:

must be robust with small differences in features,

must make fast calculations possible,

must have a strong discriminating power.

Solution

The Method According to the Present Invention

[0004] The method comprises the step of calculating, for each image, an index appearing in the form of a characteristic vector, encoding the content of the image. The index calculation process is hereinafter called the indexing process.

[0005] The method comprises the following steps using the indexing process:

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the step of calculating a reference index, using the indexing process for the specific image, or

the step of extracting reference indexes from the specific audiovisual sequence so as to form a reference set of reference indexes.

[0006] Characteristic reference indexes of the specific image and/or of the specific audiovisual sequence are thus obtained.

[0007] The method additionally comprises the step of calculating an index for current images of the flow, using the indexing process for the current images of the flow. The index thus calculated is hereinafter called the current index.

[0008] The method comprises the step of comparing the reference indexes with the current index of the current image of the flow monitored. It is thus possible to detect a specific image within a flow with great precision and extremely fast, while being robust during major photometric alterations.

Indexing Process

[0009] Preferably, according to the present invention, the method is such that, for calculating an index of an image, and in particular a reference index and/or a current index, it comprises the step of resampling the image as an image with fixed dimensions in advance. The resampled image is hereinafter called the normalized image.

[0010] If the image is a color image comprising levels of colors, the method additionally comprises the step of converting the levels of colors of the image to be resampled to levels of gray beforehand.

[0011] The normalized image is represented by a matrix of pixel values after discrete quantization of the pixel values.

[0012] The method additionally comprises the step of arranging the values according to a predetermined running order of the positions in the matrix, and in particular by concatenating the values of each line of the matrix in the form of a characteristic vector. This vector forms the index.

[0013] Preferably, according to the present invention, the method additionally comprises the step of calculating the discrete entropy of the distribution of the values of the reference index or the current index. The entropy is hereinafter called the reference marginal entropy or the current marginal entropy.

[0014] The comparison time is optimized by proceeding in this way.

[0015] The marginal entropy value may be added to the index.

Calculation of an Index Comparison Distance

[0016] Preferably, according to the present invention, the indexes appear in the form of ordered and finite sets of values. These values are identified, in the reference index and the current index, by a system of coordinates.

[0017] The method additionally comprises the step of defining, for a given coordinate of the system of coordinates, a pair of values:

of which the first value is the value appearing in the reference index associated with the given coordinate, and

of which the second value is the value appearing in the current index associated with the given coordinate.

[0018] The method additionally comprises the step of calculating the bidimensional histogram of the pairs of values obtained for all the coordinates of the system of coordinates of the reference index and of the current index.

[0019] The method additionally comprises the step of calculating the discrete entropy of the bidimensional histogram, hereinafter called the entropy of the bidimensional histogram.

[0020] The method additionally comprises the step of calculating a comparison distance between a reference index and a current index, forming the ratio between the sum of the reference marginal entropy and of the current marginal entropy reduced by the entropy of the bidimensional histogram as the numerator and the sum of the reference marginal entropy and of the current marginal entropy as the denominator.

Extraction of Reference Indexes

[0021] Preferably, according to the present invention, the method is such that, to extract reference indexes of the specific audiovisual sequence from the specific audiovisual sequence, it additionally comprises the step of initializing a reference set containing the reference indexes of specific images. This set is initialized with the reference index of the first specific image of the specific audiovisual sequence. The reference index of the first specific image of the specific audiovisual sequence constitutes the first reference index of the reference set.

[0022] The method additionally comprises:

(a) the step of calculating, for each specific image of the specific audiovisual sequence, a temporary current index and of calculating a comparison distance between the temporary current index and the last reference index added to the reference set,

(b) the step of comparing the comparison distance between the temporary current index and the last reference index added to the reference set to a predetermined threshold SE,

(c) the step of adding the temporary current index to the reference set if the comparison distance exceeds the predetermined threshold SE.

[0023] The temporary current index becomes the last reference index of the reference set.

[0024] The method additionally comprises the step of repeating the steps (a) through (c) up to the end of the specific audiovisual sequence.

Detection

[0025] Preferably, according to the present invention, the method is such that, for comparing the reference indexes with the current index of the current image of the monitored flow, it additionally comprises the step of comparing the comparison distance to a predetermined threshold SF so that the specific image is detected within

any flow of images when the comparison distance between the reference index of the specific image and the current index is less than the predetermined threshold SF.

[0026] According to another embodiment variant of the present invention, the method is more particularly designed to detect a specific audiovisual sequence within any flow of audiovisual sequences. Preferably, in the case of this embodiment variant, the method comprises:

(a) the step of initializing a variable T at -1 and of initializing a variable D at 0,

(b) the step of calculating, for each reference index of the reference set, the comparison distance between the reference index of the reference set and the current index.

[0027] If the comparison distance thus calculated is less than a predetermined threshold SD, the variable D is increased by one. This condition is hereinafter called the condition for detecting reference indexes.

[0028] The moment when the first reference index of the reference set of the specific audiovisual sequence meets the detection condition is hereinafter called the moment of the first detection.

[0029] The method additionally comprises the following steps:

(c) the step of assigning to the variable T the time elapsed since the moment of the first detection if the variable D is different from zero,

(d) the step of repeating step (b) until the variable D reaches the predetermined threshold SD, or of repeating step (a) if the variable T exceeds the predetermined threshold ST,

(e) the step of detecting the specific audiovisual sequence if the variable D reaches the predetermined threshold SD.

The System According to the Present Invention

[0030] The system comprises:

first calculation means for calculating a reference index for the specific image, using an indexing process, or

first computer analysis means for extracting reference indexes from the specific audiovisual sequence, so as to form a reference set of reference indexes.

[0031] The reference index appears in the form of an ordered and finite set of values, and in particular in the form of a characteristic vector, encoding the content of the specific image. The combination of the technical features results in that a reference index characteristic of the specific image and/or of the specific audiovisual sequence is thus obtained. The system comprises:

reception means for receiving the flow of images or audiovisual sequences comprising at least one specific image and/or at least one specific audiovisual sequence,

computer processing means for digitizing the flow of images or audiovisual sequences.

[0032] The system additionally comprises second calculation means for calculating a current index for the current images of the flow, using the indexing process for the current images of the flow. The current index appears in the form of an ordered and finite set of values, and in particular in the form of a characteristic vector, encoding the content of the current image. The system additionally comprises comparison means for comparing the reference index of the specific image with the current index of the current image of the monitored flow. The combination of the technical features results in that the system makes it possible to detect a specific image within a flow with great precision and extremely fast, while being robust during major photometric alterations.

Indexing Process

[0033] Preferably, according to the present invention, the first calculation means for calculating a reference index of a specific image comprise:

sampling means for resampling the specific image as a resampled specific image with fixed dimensions in advance,

means for the discrete quantization of the pixel values of the resampled specific image.

[0034] After discrete quantization, the resampled specific image is represented by a matrix of the pixel values.

[0035] The first means for calculating the reference index of a specific image additionally comprise sequencing means for arranging the pixel values according to a predetermined running order of the positions in the matrix, and in particular by concatenating the values of each line of the matrix in the form of a characteristic vector. The reference index is thus obtained.

[0036] If the specific image is a color image comprising levels of colors, the system additionally comprises conversion means for converting the levels of colors of the specific image to be resampled to levels of gray beforehand.

[0037] Preferably, according to the present invention, the first calculation means additionally comprise reference processing means for calculating the discrete entropy of the distribution of the values of the reference index. This entropy is hereinafter called the reference marginal entropy.

[0038] It is thus possible to optimize the comparison time. It is possible to add this reference marginal entropy value to the reference index.

[0039] Preferably, according to the present invention, the system is such that the second calculation means for calculating a current index of a current image comprise:

sampling means for resampling the current image as a current image with fixed dimensions in advance,

means for the discrete quantization of the pixel values of the current image.

[0040] After discrete quantization, the resampled current image is represented by a matrix of the pixel values.

[0041] The second calculation means for calculating a current index of a current image additionally comprise sequencing means for arranging the pixel values according to a predetermined running order of the positions in the matrix, and in particular by concatenating the values of each line of the matrix in the form of a characteristic vector. The current index is thus obtained.

[0042] If the current image is a color image comprising levels of colors, the system additionally comprises conversion means for converting the levels of colors of the current image to be resampled to levels of gray beforehand.

[0043] Preferably, according to the present invention, the second calculation means additionally comprise current processing means for calculating the discrete entropy of the distribution of the values of the current index. This entropy is hereinafter called the current marginal entropy.

[0044] It is thus possible to optimize the comparison time. It is possible to add this current marginal entropy value to the current index.

Calculation of an Index Comparison Distance

[0045] Preferably, according to the present invention, each reference index and each current index appear in the form of ordered and finite sets of values. These values are identified, in the reference index and the current index, by a system of coordinates. The system is such that it additionally comprises third calculation means for defining, for a given coordinate of the system of coordinates, a pair of values, of which the first value is the value appearing in the reference index associated with the given coordinate, and of which the second value is the value appearing in the current index associated with the given coordinate. The third calculation means make it

possible to calculate the bidimensional histogram of the pairs of values obtained for all the coordinates of the system of coordinates of the reference index and of the current index.

[0046] The third calculation means also make it possible to calculate the discrete entropy of the bidimensional histogram, hereinafter called the entropy of the bidimensional histogram.

[0047] The third calculation means also make it possible to calculate a comparison distance between a reference index and a current index, forming the ratio between the sum of the reference marginal entropy and of the current marginal entropy reduced by the entropy of the bidimensional histogram as the numerator and the sum of the reference marginal entropy and current marginal entropy as the denominator.

Extraction of Reference Indexes

[0048] Preferably, according to the present invention, the system is such that for extracting from the specific audiovisual sequence, made up of specific images, the reference index of the specific audiovisual sequence, it additionally comprises fourth calculation means. These fourth calculation means use a calculation algorithm comprising a step of initializing a reference set containing the reference indexes of the specific images. The reference set is initialized with the reference index of the first specific image of the specific audiovisual sequence. The reference index of the first specific image of the specific audiovisual sequence constitutes the first reference index of the reference set. The calculation algorithm additionally comprises:

(a) the step of (i) calculating, for each specific image of the specific audiovisual sequence, a temporary current index and (ii) of calculating a comparison distance between the temporary current index and the last reference index added to the reference set,

(b) the step of comparing the comparison distance between the temporary current index and the last reference index added to the reference set to a predetermined threshold SE,

(c) the step of adding the temporary current index to the reference set, if the comparison distance exceeds the predetermined threshold SE.

[0049] The temporary current index becomes the last reference index of the reference set. The calculation algorithm additionally comprises the step of repeating the steps (a) through (c) up to the end of the specific audiovisual sequence.

Detection

[0050] Preferably, according to the present invention, the system is such that the third calculation means compare the comparison distance between each reference index and the current index of the current image of the monitored flow to a predetermined threshold SF in such a way that the specific image is detected within any flow of images when the comparison distance between the reference index of the specific image and the current index is less than the predetermined threshold SF.

[0051] According to another embodiment variant of the present invention, the system is more particularly designed for detecting a specific audiovisual sequence within any flow of audiovisual sequences. In this case, the system comprises initialization means for loading the value -1 in a first register T and the value 0 in a second register D.

[0052] In the case of this variant, the system additionally comprises fifth calculation means for calculating, for each reference index of the reference set, the comparison distance between the reference index of the reference set and the current index.

[0053] If the comparison distance thus calculated is less than a predetermined threshold SD, the second register D is increased by one. This condition is hereinafter called the condition for detecting reference indexes.

[0054] The moment when the first reference index of the reference set of the specific audiovisual sequence meets the detection condition is hereinafter called the moment of the first detection.

[0055] The fifth calculation means are equipped for loading in the first register T the time elapsed since the moment of the first detection if the value stored in the

second register D is different from zero. The fifth calculation means are equipped (i) for repeating the calculation of the comparison distance until the value stored in the second register D reaches the predetermined threshold SD, or (ii) for repeating the use of the initialization means if the value stored in the first register T exceeds a predetermined threshold ST.

[0056] In such a way that the specific audiovisual sequence is said to be detected if the stored value of the second register D reaches the predetermined threshold SD.

Mathematical Precisions about the Nature of the Comparison Function Used in the Present Invention

[0057] The method that is the subject of the present invention makes it possible to detect proprietary audiovisual sequences within a video flow to be analyzed. This method is based on the existence of a comparison distance making it possible to compare any two images.

[0058] This function has the property of returning a low value, close to 0, when the two images are different and returning a high value when the two images are superimposable, even in the presence of significant photometric transformations between the two images, i.e., profoundly changing the pixel values of an image.

[0059] Section 1 defines the function used for the comparison, and section 2 shows why the detection takes place under the given, even difficult, conditions.

1. Mutual Information Between Two Random Variables

[0060] Originating from the field of statistics, the concepts mentioned below are known and can be found in technical works presenting the foundations of the theory of communications, for example, in Information Theory, by Robert B. Ash, Dover Publications Inc.

1.1 Concept of Discrete Entropy

[0061] If **X** is a random variable having discrete values **{x_1, ... x_n}** with the corresponding distribution of probabilities **{p_1, ... p_n}** (i.e., **p(X = x_1) = p_1, ..., p(X = x_n) = p_n)**, the discrete entropy of **X** is by definition:

$$H(X) = -\Sigma px\_i \times \log(px\_i)$$

1.2 Concept of Joint Discrete Entropy

[0062] If **X** is a random variable having discrete values **{x_1, ... x_n}** with the corresponding distribution of probabilities **{px_1, ... px_n}**;

If **Y** is a random variable having discrete values **{y_1, ... y_n}** with the corresponding distribution of probabilities **{py_1, ... py_n}**;

If the joint random variable **Z = (X, Y),** having by definition the discrete values **{(x_1, y_1), ..., (x_n, y_n)}** provided with the corresponding distribution of probabilities **{pz_11, ... pz_nn}**

in such a way that **p(X = x_1, Y = y_1) = pz_11, ..., p(X = x_n, Y = y_n) = pz_nn),**

then the joint discrete entropy of **Z = (X, Y)** is by definition

$$H(Z) = H(X, Y) = -\Sigma_{i,j} pz\_ij \times \log(px\_ij)$$

1.3 Concept of Conditional Discrete Entropy

[0063] If **X** is a random variable having discrete values **{x_1, ... x_n}** with the corresponding distribution of probabilities **{px_1, ... px_n}**;

If **Y** is a random variable having discrete values **{y_1, ... y_n}** with the corresponding distribution of probabilities **{py_1, ... py_n}**;

If the conditional discrete random variable **W = (X|Y),** declaring "**X** knowing **Y**", having by definition discrete values **{(x_1|y_1), ..., (x_n|y_n)}**

provided with the corresponding distribution of probabilities **{pw_11, ... pw_nn}**, in such a way that **p(X = x_1|Y = y_1) = pw_11, ..., p(X = x_n|Y = y_n) = pw_nn)**, then the conditional discrete entropy of **W = (X|Y)** is by definition

$$H(Z) = H(X, Y) = -\Sigma_{i,j} pw\_ij \times \log(pw\_ij)$$

It is not difficult to prove that **H(X,Y) = H(X|Y) + H(Y)**.

1.4 Concept of Mutual Information

[0064] The mutual information **MI(X,Y)** between two random variables **X** and **Y** is by definition:

$$MI(X,Y) = H(X) + H(Y) - H(X,Y)$$

$$MI(X,Y) = H(X) - H(X|Y)$$

$$MI(X,Y) = H(Y) - H(Y|X)$$

1.5 Concept of Normalized Mutual Information

[0065] The normalized mutual information **NMI(X,Y)** between two random variables **X** and **Y** is by definition given by the following formula:

$$NMI(X,Y) = MI(X,Y) / (H(X) + H(Y))$$

[0066] The concept of comparison distance entering into the definition of the technical features of the present invention corresponds to **NMI**.

1.5.1 Case of Independent Variables

[0067] If **X** and **Y** are independent, then by definition **H(X|Y) = H(X)**, and thus **NMI(X,Y) = 0**.

1.5.2 Case of Functionally Linked Variables

[0068] If **Y = f(X)**, then **H(Y|X) = H(f(X)|X) = 0**, because the value of the random variable **f(X)** is entirely determined by the knowledge of **X**. Referring to the definition of mutual information, the remarkable simplification is obtained:

$$MI(X,Y) = H(Y) = H(f(X))$$

therefore,

$$NMI(X,Y) = H(f(X)) / (H(X) + H(f(X)))$$

2. Detection of Images by Normalized Mutual Information

2.1 Images, Histograms and Random Variables

[0069] The image detection method according to the present invention is based on the definitions and properties that were just explained.

[0070] In fact:

- The normalized histogram of the levels of gray of an image **I**, obtained by calculating the histogram of the values taken by **I(x)** for **x** having all the possible positions in the image, is a distribution of discrete probabilities making it possible, by extension, to define "the entropy of an image," see paragraph 1.1.

- The normalized joint histogram of the levels of gray of two images **I1** and **I2** of the same size, obtained by calculating the bidimensional histogram of the values taken by **(I1(x), I2(x))** for **x** having all the possible positions in the image **I1**, is a bidimensional distribution of probabilities making it possible, by extension, to define "the joint entropy between two images," "the conditional entropy between two images," "the mutual information between two images," "the normalized mutual information between two images," respectively, see paragraphs 1.2, 1.3, 1.4 and 1.5, respectively.

[0071] Thus, the comparison distance used for proceeding with detections is **NMI(X,Y)**, where **X** and **Y** are two images.

2.2 Detection Criterion

[0072] To detect a specific image, the comparison distance **NMI(X,Y)** is compared to a predetermined threshold, fixed in advance. If the distance between the current image, which is the candidate for the detection, and the reference image is less than this threshold, the current image is declared "recognized" or detected.

2.3 Robustness During Photometric Transformations

[0073] In theory, the image to be detected is the exact copy of the reference image. However, in practice, the image to be detected generally has passed through a noisy transmission channel, Hertzian waves, television receiver, satellite, magnetoscope, etc. This noise may be expressed either as high-frequency noise in the image but also as a low-frequency deformation of the signal, change in contrast or in brightness, saturation, etc.

[0074] Thus, it is essential that the detection technique be robust during these photometric changes.

[0075] The distance **NMI(X,Y)** has the advantage of not directly comparing the pixel values of two images (a simple approach used, for example, in a correlation distance but unusable in practice because of its lack of robustness). On the other hand, the distance **NMI(X,Y)** has the advantage of calculating the capacity to predict the pixel values of **X** knowing those of **Y**, without a particular hypothesis about the nature of the photometric transformation linking **X** and **Y**.

[0076] In other words, the distance **NMI(X,Y)** remains minimal if **X** and **Y** correspond with one another geometrically, even if their intensity surfaces are not directly superimposable. Therefore, the detection is extremely robust during photometric changes.

Detailed Description

[0077] Other features and advantages of the present invention will become apparent after reading the description of embodiment variants of the present invention given by way of indicative and nonlimiting example and

Figure 1 which schematically shows any flow 3 of image[s] 6 containing a specific image 11, and in particular a proprietary image 4 that should be detected,

Figure 2 which schematically shows the technical means making it possible to calculate a reference index 10 of a specific image 11,

Figure 3 which schematically shows the form in which a reference index can appear,

Figure 4 which schematically shows the indexing process 39 making it possible to calculate an index 8, and in particular a current index 14 in order to compare it to a reference index 10,

Figure 5 which schematically shows a flow 3 of audiovisual sequences 7 containing a specific audiovisual sequence 2, and in particular a proprietary audiovisual sequence 4,

Figure 6 which schematically shows the technical means making it possible to calculate a reference set 30 made up of reference indexes 10 from a specific audiovisual sequence 2,

Figure 7 which schematically shows the form in which a reference index 10 of a reference set 30 can appear,

Figure 8 which schematically shows the indexing process 39 making it possible to calculate an index 8, and in particular a current index 14 of a current image 13 of any audiovisual sequence 7, in order to compare it to a reference index 10,

Figure 9 which schematically shows an embodiment of a process for indexing a specific image 11 in the case of the first embodiment variant as in the case of second embodiment variant,

Figure 10 which schematically shows an embodiment of a process for indexing a current image 13 in the case of the first embodiment variant as in the case of the second embodiment variant,

Figure 11 which schematically shows an embodiment of the pairs of values 25, 26 making up a reference index 21a and a current index 21b,

Figure 12 which schematically shows the technical means making it possible to calculate a comparison distance 29,

Figure 13 which schematically shows an embodiment of the technical means making it possible to extract the reference indexes 10 and to form a reference set 30 in the case of the second embodiment variant,

Figure 14 which schematically shows an embodiment of the technical means making it possible to detect a specific audiovisual sequence 2 in the case of the second embodiment variant,

Figure 15 which schematically shows, in the case of the second embodiment variant, the flow chart of the algorithm making it possible to detect a specific audiovisual sequence 2 using the technical means described with reference to Figure 12.

First Embodiment Variant

[0078] In the case of the first embodiment variant of the present invention which will now be described with reference to Figures 1, 2, 3 and 4, the system is designed for identifying a specific image 11 within any flow 3 of images 6. The objective is to identify a proprietary image 4 in the flow 3.

[0079] In the case of this first embodiment variant, the system comprises first calculation means 38 for calculating a reference index 10 for each specific image 11, using an indexing process 39. Such an indexing process 39 shall be described in detail below.

[0080] The reference index 10 (Figure 3) appears in the form of an ordered and finite set 21a of values 20a, and in particular in the form of a characteristic vector 9a, encoding the content of the specific image 11. A reference index 10 characteristic of the specific image 11 is thus obtained.

[0081] The system additionally comprises reception means 41 for receiving the flow 3 of images 6 capable of comprising at least one specific image 11. The system additionally comprises computer processing means 42 for digitizing the flow 3 of images 6. The system additionally comprises second calculation means 43 for calculating a current index 14 for the current images 13 of the flow 3. These second calculation means 43 calculate the current index 14 using an indexing process 39 comparable to the one used for the calculation of the reference indexes 10 of the specific images 11. Just as the reference index 10, the current index 14 appears in the form of an ordered and finite set 21b of values 20b, and in particular in the form of a characteristic vector 9b encoding the content of the current image 13.

[0082] The system additionally comprises comparison means 44 for comparing the reference index 10 of the specific image 11 with the current index 14 of the current image 13 of the monitored flow 3. It is thus possible to detect a specific image 11 within a flow 3 with great precision and extremely fast, while being robust during major photometric alterations.

[0083] An embodiment variant of the technical means making it possible to perform this detection shall be described in greater detail below with reference to Figure 12.

Second Embodiment Variant

[0084] In the case of the second embodiment variant of the present invention which will now be described with reference to Figures 5, 6, 7 and 8, the system is designed for identifying a specific audiovisual sequence 2 within any flow 3 of audiovisual sequences 7.

[0085] The objective is to identify a proprietary audiovisual sequence 5 in the flow 3.

[0086] In the case of this second embodiment variant, the system comprises first computer analysis means 40 for extracting reference indexes 10 from the specific audiovisual sequence 2, so as to make up a reference set 30 of reference indexes 10.

[0087] Each reference index 10 of the reference set 30 is calculated by calculation means 38 using an indexing process 39 comparable to the one that was

described in the case of the first embodiment variant. Each reference index 10 appears in the form of an ordered and finite set 21b of values 20b, and in particular in the form of a characteristic vector 9b encoding the content of each specific image 11 of the specific audiovisual sequence 2. A reference set 30 characteristic of the specific audiovisual sequence 2 is thus obtained.

[0088] The system additionally comprises reception means 41 for receiving the flow 3 of audiovisual sequences 7 capable of comprising at least one specific audiovisual sequence 2.

[0089] The system additionally comprises computer processing means 42 for digitizing the flow 3 of audiovisual sequences 7. In the case of this second embodiment variant, the technical means used to calculate the current index 14 of each current image 13 of an audiovisual sequence 7 will not be described. In fact, they are comparable to those described in the case of the first embodiment variant.

[0090] The system additionally comprises comparison means 44 for comparing the reference indexes 10 of the specifics images 11 making up a specific audiovisual sequence 2 with the current indexes 14 of the current images 13 of the monitored flow 3. It is thus possible to detect a specific audiovisual sequence 2 within a flow 3 with great precision and extremely fast, while being robust during major photometric alterations.

[0091] An embodiment variant of the technical means making it possible to perform this detection shall be described in greater detail below with reference to Figures 14 and 15.

[0092] The technical means, in particular the first calculation means 38 and the second calculation means 43, used to calculate the reference indexes 10 or to calculate the current indexes 14, might be combined in the same computer system; however, calculating the reference indexes 10 in systems other than those used to calculate the current indexes 14 is not departing from the field of the present invention. This remark concerns both the first embodiment variant and the second embodiment variant.

Indexing Process

[0093] In the case of the first embodiment variant of the present invention as in the case of the second embodiment variant, the first calculation means 38 and the second calculation means 43 for calculating the reference indexes 10 and the current indexes 14 use an indexing process, which will now be described with reference to an embodiment shown in Figures 9 and 10. The term "index" was used to designate a reference index 10 or a current index 14 when no distinction was made between them.

[0094] The elements having comparable functions for calculating the reference indexes 10 and the current indexes 14 were referenced with the same reference numbers in the figures.

[0095] The first calculation means 38 for calculating a reference index 10 of a specific image 11 comprise sampling means 45 for resampling the specific image 11 as a resampled specific image with fixed dimensions in advance. This resampled specific image is hereinafter called the normalized specific image 116. In order to calculate the reference indexes 10, the first calculation means 38 additionally comprise means for the discrete quantization 46 of the pixel values of the specific image 11 resampled 116. After discrete quantization, the specific image 11 resampled is represented by a matrix 19 of the pixel values 17. The first means for calculating 38 the reference index 10 of a specific image 11 additionally comprise sequencing means 47 for arranging the pixel values 17 according to a predetermined running order of the positions 18 in the matrix 19, and in particular by concatenating the values of each line of the matrix in the form of a characteristic vector 9a. The reference index 10 is thus obtained.

[0096] If the specific image 11 is a color image comprising levels of colors, the system additionally comprises conversion means 48 for converting the levels of colors of the specific image 11 to be resampled to levels of gray beforehand.

[0097] Preferably, according to the present invention, the first calculation means 38 additionally comprise reference processing means 49a for calculating the discrete entropy of the distribution of the values of the reference index 10. This entropy is hereinafter called the reference marginal entropy 50a.

[0098] The comparison time of two indexes is the time needed to calculate the comparison distance between the indexes. By adding this reference marginal entropy

value 50a to the reference index 10, the calculation of the comparison distance no longer requires the calculation of the reference entropy value 50a. The comparison time is thus reduced.

[0099] It is possible to add this reference marginal entropy value 50a to the reference index 10.

[0100] Preferably also according to the present invention, the second calculation means 43 for calculating a current index 14 of a current image 13 comprise sampling means 45 for resampling the current image 13 as a current image with fixed dimensions in advance. This resampled current image is hereinafter called the normalized current image 136. The second calculation means 43 also comprise, for calculating a current index 14 of a current image 13, means for the discrete quantization 46 of the pixel values of the current image 13. After discrete quantization, the current image 13 resampled is represented by a matrix 19 of the pixel values 17. The second calculation means 43 additionally comprise, for calculating a current index 14 of a current image 13, sequencing means 47 for arranging the pixel values according to a predetermined running order of the positions 18 in the matrix, and in particular by concatenating the values of each line of the matrix in the form of a characteristic vector 9b. The current index 14 is thus obtained.

[0101] If the current image 13 is a color image comprising levels of colors, the system additionally comprises conversion means 48 for converting the levels of colors of the current image 13 to be resampled to levels of gray beforehand.

[0102] Preferably, according to the present invention, the second calculation means 43 additionally comprise current processing means 49b for calculating the discrete entropy of the distribution of the values of the current index 14. This entropy is hereinafter called the current marginal entropy 50b.

[0103] It is thus possible to optimize the comparison time. It is possible to add this current marginal entropy value 50b to the current index 14.

[0104] The reference 16 was sometimes used to designate a normalized specific image whether it was a normalized specific image 116 or a normalized current image 136.

Calculation of an Index Comparison Distance

[0105] In the case of the first embodiment variant of the present invention as in the case of the second embodiment variant, the system comprises comparison means 44 for (i) comparing the reference index 10 of the specific image 11 with the current index 14 of the current image 13 of the monitored flow 3 or for (ii) comparing the reference indexes 10 of the specific images 11 making up a specific audiovisual sequence 2 with the current indexes 14 of the current images 13 of the monitored flow 3.

[0106] An advantageous embodiment of the technical means making it possible to perform these comparisons shall now be described with reference to Figures 11 and 12. For this purpose, the concept of comparison distance 29 in terms of the present invention should be explained.

[0107] Just as this was described above, each reference index 10 and each current index 14 appear in the form of ordered and finite sets 21a and 21b of values 20a and 20b. Therefore, it is possible to identify these values 20a and 20b in the reference index 10 and the current index 14 by a system of coordinates 22.

[0108] The system additionally comprises third calculation means 52 for defining, for a given coordinate 24 of the system of coordinates 22, a pair of values 25, 26, of which the first value 25 is the value appearing in the reference index 10 associated with the given coordinate 24, and of which the second value 26 is the value appearing in the current index 14 associated with the given coordinate 24.

[0109] The third calculation means 52 make it possible to calculate the bidimensional histogram 27 of the pairs of values 25, 26 obtained for all the coordinates of the system of coordinates of the reference index 10 and of the current index 14.

[0110] The third calculation means 52 also make it possible to calculate the discrete entropy of the bidimensional histogram, hereinafter called the entropy of the bidimensional histogram 28.

[0111] The third calculation means 52 also make it possible to calculate a comparison distance 29 between a reference index 10 and a current index 14, forming

the ratio between the sum of the reference marginal entropy 50a and of the current marginal entropy 50b reduced by the entropy of the bidimensional histogram 28 as the numerator and the sum of the reference marginal entropy 50a and of the current marginal entropy 50b as the denominator.

Extraction of Reference Indexes

[0112] Now that the concept of comparison distance 29 between a reference index 10 and a current index 14 has been explained, it is possible to complete the description of the second variant of the present invention in the case of an advantageous embodiment with reference to Figure 13. In the case of this advantageous embodiment, designed to make it possible to detect a specific audiovisual sequence 2 within a flow 3 of audiovisual sequences 7, one proceeds beforehand with a phase of extracting reference indexes 10 so as to form a reference set 30.

[0113] To extract the reference indexes 10 of the specific audiovisual sequence 2 from the specific audiovisual sequence 2, made up of specific images 11, the system additionally comprises fourth calculation means 53. These fourth calculation means 53 use a calculation algorithm 54 comprising a step of initializing a reference set 30 containing the reference indexes 10 of specific images. The reference set 30 is initialized with the reference index 100 of the first specific image 110 of the specific audiovisual sequence 2. The reference index 100 of the first specific image 110 of the specific audiovisual sequence 2 constitutes the first reference index of the reference set 30. The calculation algorithm 54 additionally comprises:

(a) the step of (i) calculating, for each specific image 11 of the specific audiovisual sequence 2, a temporary current index 31 and (ii) of calculating a comparison distance 29 between the temporary current index 31 and the last reference index 32 added to the reference set 30,

(b) the step of comparing the comparison distance 29 between the temporary current index 31 and the last reference index 32 added to the reference set 30 to a predetermined threshold SE 33,

(c) the step of adding the temporary current index 31 to the reference set 30, if the comparison distance 29 exceeds the predetermined threshold SE 33.

[0114] The temporary current index 31 thus becomes the last reference index 32 of the reference set 30. The calculation algorithm 54 additionally comprises the step of repeating the steps (a) through (c) up to the end of the specific audiovisual sequence 2.

Detection

[0115] The final phase of the method of detecting the specific image 11, and in particular the proprietary image 4, within any flow 3 of images 6 shall now be described in the case of the first embodiment variant with reference to Figure 12. For this purpose, the third calculation means 52 compare the comparison distance 29 between each reference index 10 and the current index 14 of the current image 13 of the monitored flow 3 to a predetermined threshold SF 65. The specific image 11 is said to be detected within any flow 3 of images 6 when the comparison distance 29 between the reference index 10 of the specific image 11 and the current index 14 is less than the predetermined threshold SF 65.

[0116] The final phase of the method of detecting the specific audiovisual sequence 2, and in particular the proprietary audiovisual sequence 5, within any flow 3 of audiovisual sequences 7 shall now be described in the case of the second embodiment variant with reference to Figures 14 and 15. In this case, the system comprises initialization means 57 for loading the value -1, minus one, of a variable T 34, in a first register T 55, and the value 0, zero, of a variable D 35, in a second register D 56.

[0117] In the case of this embodiment variant, the system additionally comprises fifth calculation means 58 for calculating, for each reference index 10 of the reference set 30, the comparison distance 29 between the reference index 10 considered of the reference set 30 and the current index 14 of a current image 13 of the monitored flow 3.

[0118] If the comparison distance 29 thus calculated is less than a predetermined threshold SD 59, the second register D 56 is increased by one. This condition is hereinafter called the condition for detecting reference indexes 10.

[0119] The moment when the first reference index 10 of the reference set 30 of the specific audiovisual sequence 2 meets the detection condition is hereinafter called the moment of the first detection.

[0120] The fifth calculation means 58 are equipped for loading in the first register T 55 the time elapsed since the moment of the first detection if the value stored in the second register D 56 is different from zero. The fifth calculation means 58 are equipped (i) for repeating the calculation of the comparison distance 29 until the value stored in the second register D 56 reaches the predetermined threshold SD 59, or (ii) for repeating the use of the initialization means if the value stored in the first register T 55 exceeds a predetermined threshold ST 60.

[0121] In such a way that the specific audiovisual sequence 2 can be said to be detected if the value stored in the second register D 56 reaches the predetermined threshold SD 59.

[0122] Figure 15 shows the flow chart of the algorithm that was just described.